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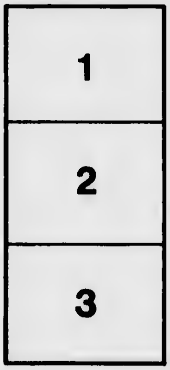
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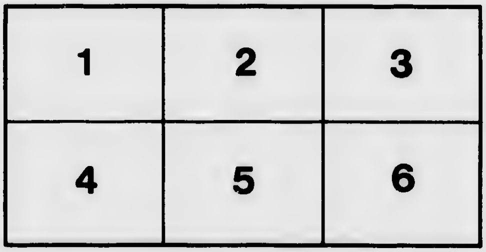
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THE CANADIAN MONTHLY AND NATIONAL REVIEW.

Vol. 8.] SEPTEMBER, 1875. [No. 3.

THE ICE PHENOMENA AND THE TIDES OF THE BAY OF FUNDY,

Considered in connection with the construction of the Baie Verte Canal.

BY HENRY Y. HIND, M.A., WINDSOR, N.S.

I. THE BAIE VERTE CANAL.

THE BAIE VERTE CANAL is a contemplated work designed to connect the waters of the Gulf of St. Lawrence, at Baie Verte, with those of the Bay of Fundy, at Cumberland Basin. It will cross an isthmus between these Atlantic Ocean waters, fifteen miles and one quarter in breadth at the narrowest part; the lowest summit on the isthmus being of a soft marshy nature, and elevated only five feet above the level of a tidal wave which occurred in the Bay of Fundy, on the 5th Oct., 1869; and 9 feet above a tide observed on the 25th Oct., 1870.* The tidal waters of the Gulf of St. Lawrence and the Bay of Fundy approach within $6\frac{3}{4}$ miles under ordinary conditions, and at certain periods the water in Cumberland Basin is eighteen and a half feet above that in Baie Verte, but during ebb tides the water in Baie Verte is nineteen and a half feet higher than that in Cumberland Basin.†

The boundary line between the Provinces of Nova Scotia and New Brunswick is twice intersected by the route adopted for the proposed navigable channel of communication.

The reports on the Baie Verte Canal by the Chief Engineer of Public Works (Mr. Page), and by the Assistant Chief Engineer, (Mr. G. F. Baillairgé), embrace valuable and interesting information respecting the physical geography of part of the Bay of Fundy, and particularly of the isthmus separating its waters from those of Baie Verte in the Gulf of St. Lawrence; but these reports are in the main devoted to the engineering details and novelties inseparable from the undertaking, which, the Chief Engineer states, is attended with unusual difficulties.

The opening of a communication between the waters of the Bay of Fundy and Baie Verte has been discussed periodically since the year 1822,* but in none of the reports to

* Report of the Chief Engineer of Public Works.
† Ibid.

* *Vide* "Synopsis of Reports on the Baie Verte Canal, published by the Department of Public Works.—1. Rob. C. Minnitte, P. L. S., 1822; 2. Francis Hall, C. E., 1825; 3. Thomas Telford, C. E., 1826; 4. H.O. Crawley, Capt., R. E., 1843; 5. John Page, Ch. En., P. W., 1869; 6. G. F. Baillairgé, Assistant C. E., P. W., 1872; 7. Canal

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which I have had access have certain geological and physical phenomena been referred to, which cannot be ignored in the discussion of a work involving such difficulties, and attended with such enormous outlay, as the proposed Baie Verte Canal.

Questions connected with the physical geography of the country traversed, and more particularly its hydrography and geology, obtrude themselves constantly in an examination of the details of this great project. It is as much a geological and hydrographical as an engineering problem. It really involves at the very outset of the enquiry the problems incident to the action, influence, and history of the tides in the Bay of Fundy; the formation of the isthmus across which the canal is to be built; and, perhaps greater than all, it involves the most careful examination into the probable future behaviour of the tides with respect to the impediments, in the shape of piers, which are proposed to be thrown in the way of their resistless and never ceasing energies. Many of the details included in this notice of the Baie Verte Canal have been written for a work, now in an advanced state of preparation, entitled "The Dominion of Canada," the publication of the first part of which is delayed for the purpose of introducing the results of recent highly important surveys within the limits and near the borders of the Dominion. But as the official notice inviting contractors to tender for preliminary works on the canal has already been issued by the Department of Public Works, I have thought that a brief sketch of the geological and hydrographical features of the question, chiefly drawn from the manuscript work before referred to, might embody suggestions worthy of consideration, or direct enquiry towards certain phenomena peculiar to the Bay of Fundy and similarly situated water areas, or tend to avert possible contingencies arising from tidal ice and uncontrollable currents which might impede the progress of the stupendous work now about to be begun.

2. THE "EYGRE" OF THE BAY OF FUNDY.

I was an eye-witness of the effects produced in some parts of the Bay of Fundy by the so called "Saxby Storm," in October, 1869, and I still retain a vivid recollection of the grandeur and power of the advancing sea over the wide-spreading dyked lands on the borders of the Bay, and of the impotency of the dykes as they now exist, to restrain the bounds of the great tidal wave—the "eygre" of our forefathers—when it exceeds its normal maximum range.

The "Saxby Storm" rose but four feet above the highest water observed during Mr. Baillairgé's survey, and I suppose about the same elevation above the dykes of Cumberland Basin; but if we are to credit the accounts of the storm on the 3rd of November, 1759, to which reference will be made subsequently, the tidal wave rose *ten* feet higher than the tops of the dykes near Fort Cumberland on the Baie Verte isthmus.

To those who are not "dwellers by the sea," and have not had opportunities for forming a mental picture of a great tidal wave surging upon a dyked coast and breaking down the barriers, the beautiful description by Jean Ingelow, of the High Tide on the Coast of Lincolnshire, in 1571, may give an impress,

"For lo! along the river's bed,
A mighty Eygre* reared its crest,
And uppe the Lindis raging sped.
It swept with thunderous noises loud;
Shaped like a curling snow-white cloud,
Or like a demon in a shroud.

And rearing Lindis backward pressed,
Shook all her trembling bankes amaine;
Then madly at the Eygre's breast
Flung uppe her weltering walls again.
Then bankes came downe with ruin and rout
Then beaten foam flew round about
Then all the mighty floods were out.

So farre, so fast, the Eygre drave,
The heart had hardly time to beat,
Before a shallow, seething wave,
Sobbed in the grasses at oure feet:
The feet had hardly time to flee
Before it brake against the knee,
And all the world was in the sea."

Commissioners, 1871; 8. Messrs. Keefer and Gzowski, 1872; 9. Messrs. Keefer and Gzowski, 1873; 10. G. F. Baillairgé, 1873; 11. G. F. Baillairgé, 1873; 12. J. Page, Ch. En., P. W., 1873.

* "Eygre"—bore—tidal wave, in strait, estuary, or river. There is no "bore" in the *channel* of Cumberland Basin, owing to its great depth, but there is a bore or "eygre" on the sandy flats, and in several estuaries and rivers, particularly the Petitcodiac.

References are made to the tidal wave of November, 1759, in various public documents of the period, but the most precise notice is quoted in Bearnish Murdoch's History of Nova Scotia, from the *Gentleman's Magazine*, 1760, page 45.

"The storm brake down the dykes on the Bay of Fundy everywhere, and the marsh lands now deserted, were overflown and deteriorated. At Fort Frederick, on St. John River, a considerable part of the Fort was washed away, and at Fort Cumberland, 700 cords of firewood was swept off by the tide in a body from the woodyard, although situated at least ten feet higher than the tops of the dykes."*

For the sake of brevity I shall quote the conclusions of reliable authorities on certain points, leaving to the reader, if he is so disposed, the study of the arguments advanced by the author to whom reference is made.

3. SOME OF THE PHYSICAL FEATURES OF THE ISTHMUS.

In an elaborate report "On the Reclamation of Tide-lands, and its Relation to Navigation," by Henry Mitchell, Chief in Physical Hydrography, United States Coast Survey (1869), the following proposition is established. "The nearly horizontal surfaces of the marshes are at the *plane of mean high water!* Mr. Baillairgé states, in his report on the Baie Verte Canal, that the surface of the marshes and bogs on the isthmus for more than seven miles inland is from one to three feet *lower* than the average range of mean spring tides; and it appears from the tables showing the range of the tides, that the surfaces of the marshes and bogs around Cumberland Basin are:

From one to three feet below the plane of average high water;
" five to seven feet below the maximum range of high water;
" six to nine feet below the highest water observed during the survey;
" ten to thirteen feet below the Saxby tidal wave.

Mr. Mitchell adopted as his plane of mean high water the mean of highest springs and the lowest neaps. Taking the same recorded from Mr. Baillairgé's observations, we have—

Average maximum springs	44.08.
Average minimum neaps..........	35.71.
Mean.........	39.89.
Average mean range of high water, by daily observation......	39.77.
Difference.........	00.12.

The difference being only twelve hundredths of a foot, the two means may be considered identical.

It has been observed by Dr. Dawson* that the inner or low marshes, especially those near the upland and consequently most remote from the sea-board, are lower than those which form as it were the beach; and this is borne out by the observations of Mr. Baillairgé. But there is a point of interest in the altitude of the surface and bottom of the lakes at the head of the tidal rivers in the isthmus, such as the Missaquash and the La Planche, which deserves attention.

At the head of the La Planche the surface of Round Lake, in July, was found to be 94.06, or 44.06 feet above ordinary low water spring-tide, or at the same elevation as the average maximum range of high water, being 4.31 feet above the theoretical plane of the marshes. Long Lake was found, at the same date, to be 2.39 above the same plane. The average bottom of this lake is 1.77 feet below the plane of the marshes. The level of the lakes at the head of the Missaquash River is about 1½ feet above Round Lake. All of these lakes lie near the centre or middle of the isthmus.

Mr. Stark, who was instructed by Mr. Keefer to conduct a survey for the Canal, states generally that "from the summit towards the Bay of Fundy, and at the head of the Amherst Marshes, the country is inundated and dotted in all directions with small lakes, the water in which stands at a nearly uniform elevation of 92.00 above the datum line" (42 above low water spring-tides, or 2.23 feet above average mean range of high water), "or 22 feet above the Canal bottom and even with the surface of the marshes. In the great storm known as the Saxby tide, the water of the Bay of Fundy rose to an elevation of 100.00 feet above datum, and consequently flooded both these lakes and

* Murdoch's History of Nova Scotia, Vol. II., p. 376.

* Acadian Geology.

marshes to a depth of eight feet." On the summit to which reference is made in the preceeding paragraph Mr. Stark found a level plain, consisting, "to a depth of from ten to twenty feet, of moss, lying upon the bed of a lake which its formation had buried." Mr. Stark found the highest elevation of this moss at the summit 118 feet above datum, "and taking from this the depth of the moss already described, or 20 feet, will leave the elevation of the solid ground only 28 feet above the canal bottom or 10 feet above the marsh level." One hundred and eighteen feet above datum, less 20 feet of moss, is 98 feet above datum, or two feet less than the height attained by the Saxby tidal. Is is clear, therefore, that if this moss were drained and burned, according to Mr. Keefer's suggestion (*vide* Report), another "Saxby Storm" would have an uninterrupted sweep across the Isthmus, and temporarily establish water communication. A storm like that which occurred in 1759 would make quick work of the marshes and floating bogs, and probably reduce the isthmus to a permanent strait at high water, with continually increasing depths in the channel. In fact, according to Mr. Stark's Report, there appears to have been nothing but a bank of spongy "moss," a quarter of a mile in width, a mile-and-a-half in length, and of a depth varying from 10 to 20 feet, "*which prevented the Saxby tidal wave from converting Nova Scotia into an Island during the night of October, 1869, and the storm of November, 1759.*"

Now, if these marshes or masses of spongy moss be drained by the Canal, consolidated and compressed, what is to prevent another Saxby storm from sending a tidal wave by the side of the Canal from the Bay of Fundy to Baie Verte?

Nor is the mossy plain, referred to in Mr. Stark's Report as having 20 feet of moss in its deepest part, the only low summit between the Bays. Mr. Baillairgé found in the contemplated line of Canal the summit to be but five feet over the Saxby tide, and "the surface of this ridge is of a soft marshy nature, under which there is, for the most part, clay resting on red sandstone" (Mr. Page). The report does not state the depth of the soft, marshy material reposing on the clay, but as the summit is only five feet above the Saxby tidal wave, the clay may not exceed the altitude of the solid summit on Mr. Keefer's line, and notwithstanding the careful character of the borings conducted on the summit of the watershed, may there not be a still lower depression than those discovered?*

Mr. Alex. Monro, P.L.S., conducted borings in the mossy plain at the summit above described, and found the thickness of the moss to vary from 9 to 13 feet, but below this bed of moss there was an accumulation of fallen timber. "The crust of the plain for a depth of about 5 feet is composed of roots and live moss; below this depth the material appears to consist of rotten moss and decayed vegetable matter, resting upon the fallen timber of a buried forest, probably accumulated centuries ago, the whole resting on clay and red sandstone rock." The "buried forest" is probably drift wood. The evidence of rooted stumps would be required to entitle it to the name of "buried forest."

4. THE SUBMERGED FORESTS.

The submerged forests at the head of the Cumberland Basin, have been described by Dr. Dawson, with his usual clearness and detail, in his well known work, "Acadian Geology." The valuable information there given and illustrated, is supplemented in the Departmental reports of the survey of the Baie Verte Canal, by plans and sections, showing the position of the submerged forests and their present depths, which leave nothing to be desired respecting their origin; it being incontestably shown that they represent two belts of former upland forests, now submerged to the depth of about 21 and 32 feet below the plane of the marshes.†

Now the first question with which we have to grapple is this: Do these submerged forests indicate a subsidence, as Dr. Dawson suggests, to the extent of about 40 feet, or are they the results of *denudation*, through the influence of the tides, and represent a landslide?

Two years ago I had an opportunity of watching the progress of several patches of grass-covered turfy soil, resting on a sandy substratum, and recently detached from the

* Notes respecting underground forests. Appended to Baie Verte Canal Reports.

† "It only remains to believe that a subsidence has taken place over a considerable area, and to a depth of about 40 feet."—*Acadian Geology, page* 31.

main land, slowly sliding over the smooth surface of tidal mud, near the mouth of Bass River, Five Islands, in the Bay of Fundy. To the best of my recollection, the largest surface may have been about one hundred and fifty feet in length, and about twenty-five in breath. When last seen it was about ten or twelve feet below the surface of the formerly spruce-covered level track from which it had been disengaged *en masse*. Near to it lay smaller patches of the same turfy soil, but lower down the gently sloping beach. The description given by Mr. Baillairgé of the turfy soil resting on sand which prevails under the marshes and bogs of the Baie Verte isthmus, has forcibly suggested to me the probability that these formations may be contemporaneous, and adds another proof to the opinion I have long entertained, that the submerged forests and peat bogs found beneath the sea, belonging to this period, are land slides, and represent a phenomenon which is of very wide spread occurrence on the whole Atlantic coast, from the Bay of Fundy to Florida, belonging to an important geological change going on under our eyes.

It is due to Mr. P. S. Hamilton, formerly Commissioner of Mines in Nova Scotia, to state that many years since he advocated the view that the submerged forests of Cumberland Basin represented land slides.*

The sheet of cross section accompanying Mr. Baillairgé's report, shows in all details the requisite conditions for a land slide, in which the moving mass might preserve its integrity throughout. There is the gentle slope seawards of the rock, ascertained by borings, the substratum of clay, or perhaps tidal mud, reposing upon the rock, the peaty soil in which the submerged trees are still rooted, like the peaty substratum underlying the bogs and marshes; and then we have the ever varying change in absolute weight of the sliding mass, by being saturated and drained twice a day by tidal water, to destroy stable equilibrium, and induce gentle motion down the inclined plane. Again, the range of the landward boundary of the submerged stumps and fallen trees is very nearly the same as the present range of the borders of marshes or coast line at the mouth of the Cumberland Creek, a remarkable and suggestive parallelism.

Any one familiar with the rich dyked lands of the Bay of Fundy will recall to mind numerous "Islands" in the level expanse of the marsh lands, which still maintain a wooded surface and present nearly vertical cliffs of drift clays and gravel, with the usual talus, showing the presence at one time of wooded upland over what are now wide areas of the richest marsh. But on some portions of the Maccan and Hebert rivers, we can now see the low upland clothed with forest growth, swept during high tides to the very base of the cliff. As Mr. Hamilton suggests, in the paper before referred to, these may be undermined, and in favourable positions portions of them may slide bodily down. The jar produced by an earthquake, of which we have had upwards of thirty recorded instances since the country was settled, would be quite sufficient to begin the movement of the matted mass of roots over a large and unbroken surface, especially if inclined on a sandy substratum towards the invading tidal waters.

But there is another cause for the initial movement which operates to a great extent in this climate in denuding sloping banks, namely, the effect of the thaw in spring. The soil on the north side of slopes is often frozen to the depth of three or more feet. During early spring the ground thaws to the depth of two feet, a heavy rain occurs and loosens the thawed mass, which slides over the still frozen substratum.

There exists, moreover, a grave geological objection to the theory which supposes these stumps to represent a forest submerged by a subsidence of the area to an extent of about forty feet, which appears to me to be fatal. Let us restore this submerged forest to its original position by an imaginary re-elevation of the land, what then becomes of Cumberland Basin? It must rise with the forest, and if so, Cumberland Basin would become a narrow river channel, without we assume that the Minudie Marshes, styled the Elysian Fields, cover an old channel by which the waters of the Hebert and Maccan found their way to the sea, and even this supposition would necessarily so circumscribe the area of subsidence, that it must have partaken of the nature of a downthrow fault, of which there is no evidence, and it must have occurred at such a remote period as to permit

* "On submerged forests in Cumberland Basin," by P. S. Hamilton. Transactions of the Nova Scotian Institute of Natural Science. Vol. II. Part II. p. 94.

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of the excavation of a part of the Macan and Hebert valleys, and the substitution of the wide spreading dyked marshes, which now enrich them. The period of time involved for this work of erosion and substitution would have been sufficient for the total destruction of all traces of the submerged forest.

I need scarcely state that while being disposed to attribute the submerged forests of Cumberland Basin to a land slide, similar to the slides now actually taking place, I recognise a general and wide-spread subsidence and elevation of the whole of Eastern North America, and have in my preliminary report on the Geology of New Brunswick, given numerous illustrations and measurements; but I am disposed to think that these movements of the crust belong to an order of geological changes which are progressing on a vast scale, and carrying down from remote epochs to the present hour, but with geological slowness, the folding of the crust as during the Appalachian period. If all the known points of present elevation and depression in Eastern America be correctly plotted on a map, and joined by continuous lines, I think they will be found to indicate a series of anticlinal and synclinal folds, parallel to those which have already determined the superficial outline of the country. But I do not think that we can class the submerged forests of Cumberland Basin as among the evidences of this wide-spread movement. I think they are extremely local, recent, and may occur at any moment in some parts of the tidal rivers, estuaries, bays, and basins of the Bay of Fundy, and that we have evidence going on before our eyes of a similar submergence by means of slides.

The depression of the marshes from one to three feet below the plane of mean high-water is just as much an evidence of the tides rising locally higher than formerly, considering the changes which have taken place during the last hundred and fifty years in limiting the expanse over which they formerly spread their waters, as it is of a terrestrial local subsidence, partly due to consolidation, although the depression below the mean level of high water is a little greater than shown by the observations recording the tidal range, for these were not taken during the night time.

5. LOCAL INCREASE IN THE HEIGHT OF THE TIDES.

There is really no objection to the view that the tides may be locally rising higher than formerly in Cumberland Basin. The mean height of the tides in secluded bays is constantly changing with the increase or decrease of the sectional area opening into the bay, allowing a greater or less body of water to pass in with corresponding variable momentum.

Mr. Mitchell* compared the marshes on the two shores of the narrow isthmus between Cape Cod and Buzzard's Bays, and found that the marshes on either side differed but about one-tenth of a foot from the local elevation of mean high-water; but the marshes on the Cape Cod Bay side are two and a half feet higher than those on the Buzzard's Bay side, and this is the difference in the mean height of high-water in either Bay. These bays being within six miles of one another, facing an open sea, afford an admirable illustration, not only of the truth of the proposition that the plane of the marshes is that of mean high-water, but also of the variable altitude of the tides in bays close together, and similarly situated with regard to the ocean.

It also shows that a change in the coast line, or the deepening of the channel into a bay, may increase or diminish the elevation of the tides, and this appears to have been the case in Cumberland Basin. An increase in the mean height in the tides in this secluded area would be readily produced by the erosion and deepening of the channel between Boss Point and Peck's Point, where the strait is about a mile and a half broad, with a depth of upwards of seventy feet; but if this local increase in the height of the tides in Cumberland Basin has taken place by the greater influx of tidal water through the strait named, it must have occurred since the dyking of the marshes, and we may, therefore, anticipate its *continued increase* as the wear of the strait progresses. The limiting of the area over which the tidal water coming through the deep strait at Boss Point spreads itself must also cause an elevation in the height of the tide, and this limiting process has been going on since the settlement of the country, by the dyking of the marsh lands.

* N. S. Coast Survey.

Near the mouth of the Shubenacadie River the evil effects of silting, as far as the navigation is concerned, have exhibited themselves in a remarkable manner, in strict agreement with the law enunciated. Not more than thirty years ago, according to Mr. Hamilton,* vessels of from fifty to one hundred and fifty tons were accustomed, almost daily, to sail up Cobequid Bay, to receive and discharge cargo at a place where it is now bridged, a short distance below the town of Truro. At the present day no attempts are made to take any sort of craft above the class of an open boat further up the bay than Yuill's Island, which is about six miles below the bridge.

The area of dyked marshes in Nova Scotia and New Brunswick is about 120,000 acres, and to the extent of the area thus represented have the limiting effects of human agency as yet succeeded in confining the tidal waters. As the great flaring mouth through which they enter remains the same, some increase in height of the tides has taken place, and it will probably be only locally felt. The difference between the plane of high water and the level of the marshes observed by Mr. Baillairgé is due, in part, to natural subsidence, and consolidation of the marsh mud, and in part to the increase in the height of the tides in Cumberland Basin, on account of the limiting process pursued by dyking the marshes and excluding the tidal waters from areas formerly covered by them during high springs.

6. THE ICE PHENOMENA OF THE BAY OF FUNDY.

The appearance of an estuary in the Bay Fundy at any time in midwinter presents some singular and striking phenomena, which may contribute to our knowledge of the manner in which different agents have assisted in excavating this extraordinary bay, and are now engaged in extending its domains in some directions and reducing it in others.

Within an hour or so of flood tide the estuary is seen to be full of masses of floating ice, mud-stained and some times, but not often, loaded with earth, stones, or pieces of marsh. The tide, flowing at a rate of four or five miles an hour, rushes past with its broad ice-ladened current until the flood. At [illegible] of variable [illegible] brief period all is repose [illegible] soon as the ebb begins, the [illegible] blocks of ice commence to move, and in half an hour they are as swiftly [illegible] noiselessly toward the sea an hour before they swiftly and noiselessly glided from it. It produces in the mind of one who sees these ice streams for the first time, moving up the wide river faster than he can conveniently walk, a feeling of astonishment akin to awe, which is heightened rather than diminished if he should return to the same point of view half an hour later, and find the ice stream rushing as impetuously as before in exactly the opposite direction.

During the ebb tide many of the larger blocks ground on the sand bars, so that when the tide is out the extensive flats are covered with ice-blocks innumerable. If the period between the ebb and the return of the flood is very cold, the stranded ice-blocks freeze to the sand-bars or mud-flats and are covered by the returning tide, but only until the warm tidal water succeeds in thawing the frozen sand or mud around the base of the ice-block, and it is enabled, by means of its less specific gravity, to break away with a frozen layer of mud or sand attached to it. It reaches the surface of the water with a bound, and is instantly swept away by the incoming tide. The spectacle thus presented by an extensive sand-bar after a few hours of freezing weather, is most extraordinary; the whole surface of the flood or ebb becomes suddenly alive with blocks of ice, springing up from below, each carrying away its burden of sand or mud frozen to its base. Later in the season, towards the middle of March, this singular phenomenon can be seen to the best advantage, and it is curious to watch a block of, say, ten feet square by five or six in thickness, being gradually covered by the tide until it becomes lost to view for an hour or more, during which time the water may have risen three or four feet above it. "When least expected" up the submerged mass springs; it has broken loose from the frozen bottom, it seems to stagger and pause for a few moments at the surface, and then joins the rest of the icy stream on their monotonous journey, until it is again stranded on some other flat or bar during the ebbing tide. But this is only a small part of the history of these ice-blocks,

* Transactions of the Nova Scotian Institute, 1866-67.

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during neap tides it often happens that block is stranded in such shallow water the flood has not power to raise it from substratum to which it is frozen. The ck grows there with every tide; fresh s of ice and tidal mud form all round it times during every twenty-four hours. eceives accessions from falling snows, by the time the spring tides begin, it greatly increased in size and is more ly frozen or weighted to the sand-bar. en the spring tides may not have the ver to free it from its icy bonds if the ather has been extremely cold; the conse-nce is that it goes on increasing in size, actually becomes a miniature berg, con-ning some thousands of cubic feet of ice l mud, and still retaining a buoyancy ich will enable it after a thaw during high ing tides to break away with a load of bris, and carry it either out to sea or up estuary, and if it should chance to be anded again, it will probably leave a por-n of its burden, provided it has not lted off during its voyage with the tide. t there can be no doubt that some of the ached sand, mud, or shingle is melted off ring the journey of the block or miniature rg, and drops into the bed of the river or uary. In reality, these ice-cakes, when in otion, are perpetually strewing the bot-n with transported material and bringing portion from one place to another, during out five hours of the flood, and carrying rt of it back again, during five hours of b, to the limits of the backward and for-rd tidal range of each particular ice-cake. t when they accumulate in an eddy, they come powerful carriers and depositors of tritus, and if artifical obstructions be in-oduced so as to form an eddy in the usual urse of the ice-stream, the accumulation ust necessarily be very rapid.

The extent of the range of the ice-blocks d the difference in the transporting power the ebb and flood, compel us to examine ore closely into the phenomena of the Bay Fundy tides.

Before, however, proceeding to glance at me of the leading features of the tides, it ay be well to point out another peculiarity the growing blocks of stranded ice during old winters. In the Avon and its estuary, locks sometimes increase in size and weight y constant accession of mud and ice and now to such an extent that they remain undisturbed by the highest spring tides and attain dimensions which are fairly represented by a mass twenty feet long, twenty feet broad, and sixteen feet high, thus containing upwards of 6,000 cubic feet of alternate films of ice and tidal mud. This season the blocks have frequently exceeded these dimensions. As spring approaches, the tidal waters melt the base far more rapidly than the sun's rays have power to dissolve the upper portion. The mass gradually assumes the form of an inverted pyramid and finally tumbles over on its side and breaks into pieces. At the time I am now writing, (26th January, 1875), the sandy flats of the Avon are covered with innumerable blocks of mud-ice, daily increasing in dimensions and weight, owing to the prolonged cold weather of the past month. The flood tide brings from the lower part of the estuary a mass of ice-cakes which completely covers the broad upper part of the estuary; stranded blocks, frozen to the mud and sand banks, burst up after the tide has risen a few feet over them, and the force of the concussion lifts the cake, swiftly drifting over it; and this is taking place over an area as far as the eye can reach, up and down the estuary, and covering many square miles of surface. The newly fallen snow has sprinkled the surface of the floating blocks with a spotless canopy of white, which contrasts strangely with their mud-stained sides. The whole scene, indeed, is one well fitted to convey an idea of the power which has been instrumental in excavating many of the broad estuaries which form the outlet of rivers flowing into the upper portion of the Bay of Fundy, for this army of mud, sand, and shingle carriers is ceaselessly at work, day and night, for four months in the year, in every estuary and on every broad sand-bank and mud flat in the Bay.

The impression produced on the mind by this spectacle is not a pleasant one. In calm weather, or during the prevalence of winds in one quarter, the scene, so often repeated, becomes painfully monotonous, as frequently one can recognise among the passing host a well known ice block in the mid stream, and safe from sand-bars, with some distinguishing mark upon it. Day after day it swiftly drifts with the flood tide "up stream," and in an hour or so with equal eagerness drifts seawards with the ebb, but owing to the eternal flow of the Bay of Fundy tides, hereafter described, reappearing the next day slightly increased in size, with the same eager rush, and so on for days and sometimes weeks together. Nor is the weary impression softened by the reflection that the greater portion of the passing host have been engaged in travelling over precisely the same route in dull uniformity throughout the winter's nights, and will continue to do so, until a change in the direction of the wind drives them out to sea, but only to take up another "line of march" in another direction.

It will be observed from the foregoing description, that the action of ice in the tidal rivers of the Bay of Fundy is of a totally different character from the *modus operandi* of ice in such rivers as the St. Lawrence, beyond the reach of the tide. There, all the transporting effects are directed down stream, as is so graphically described by Sir William Logan, in his paper on "the Winter Phenomena of the St. Lawrence." Ice in the Bay of Fundy rivers and estuaries, and even on its coasts, has a tenfold greater excavating and transporting power than in rivers where no tide exists, in continually repeating the operation, and making the same block of ice carry material to and fro, for months together, and up stream as well as down. Hence the reason why the estuaries of insignificant streams are of such gigantic dimensions on the upper part of the Bay of Fundy shores, and perhaps we may find an explanation of the origin of many great valleys now occupied by small rivers, in which tidal currents prevailed during a colder epoch, and during a period of submergence. It may serve also to explain the origin of drift containing fragments originating from strata far down the streams where such deposits occur, and which are not found *in situ* up stream.

It is curious to watch the action of ice accumulating on the wharves and between wharves in such harbours as Windsor, and others on the coast, where the tide rises thirty feet or more.

The ice grows with great rapidity on the sides exposed to the tide. During prolonged seasons of very cold weather, it acquires a great thickness, sometimes of ten to twenty feet. Between the wharves the ice will meet, and actually fill up the intervening basin or slip, forming a solid mass twenty feet thick. When spring comes with its genial warmth, and se[illegible] harbour free, the mass on the outside of the wharf or pier suddenly rises with a high spring tide, becomes detached and floats away. Not so, however, the ice between two wharves forming a slip; it remains firm for weeks after the fringe has separated from the outside; it is not only held on both sides, but also at the bottom, for the sweep of the tide can undermine it but slowly. I have asked the opinion of persons well acquainted with this serious obstruction to navigation during the early spring, and have been told that the ice sometimes remains a month longer between wharves than outside of either. The "slip" formed by the piers at the Bay of Fundy entrance to the Baie Verte Canal, will be 250 feet broad and 1100 feet long. Is it not worth while to consider how long the mass of tidal ice which would be formed in it (perhaps having an average of thirty feet in thickness, 250 feet in breadth, and 1000 feet in length,) would require to thaw to the extent necessary to permit of its removal. How long would it remain after navigation was open? The tide undermines the exterior ice on the outside walls of the slip, and it is constantly lifted a little at the flood, until it becomes too feebly attached to resist the strain, and breaking, goes off *en masse*. It resembles a glacier "calving."

Sometimes land slides occur in the estuaries, and during their past history vast numbers must have taken place on a large scale. The tides soon assort the materials, carrying off mud and sand, and leaving a cordon of boulders or masses of rock. Ice cakes during winter get jammed between these masses of rock, and growing with each tide they gradually increase and accumulate to such an extent that, when a high spring tide occurs, the whole mass starts, and if near the flood floats up stream for a mile or more; the repetition of this may carry them further up stream, or away towards the sea with the ebb; but it is clear that, as with small fragments, we have the means of transporting masses of rock against the stream, and far beyond their position when *in situ*, and in a contrary direction to that of the supposed prevailing drift.

An "Ice Jam."

As already stated, the upper part of estuaries in the Bay of Fundy becomes choked with ice blocked during and at the close of the flood tide. The estuary of the Avon at Windsor is so choked with every flood tide that for miles nothing but a rough and stationary ice field is seen for half an hour before high water, during the stand, and for half an hour after the beginning of the ebb. During this interval, let us suppose, as is not unfrequently the case in this changeable climate, that it rains. It may appear strange to say that the innumerable blocks freeze together, independently of *regelation*,* for the temperature of the ice just beneath the surface is below the freezing point, except after a prolonged thaw, and the rain trickles through the interstices between the blocks, and binds them together in one solid sheet. I have been credibly informed that even in the upper portion of the Avon, where the estuary is three thousand feet broad in the channel, but several miles broad including the low dyked lands, instances have occurred when the ebb tide is incompetent to carry the sheet of ice with it; it then sinks with the retiring waters, and rests on the bottom of the tide way. But as the central part has to sink from thirty to forty feet according to the condition of the tides, whether springs or neaps, it is broken into large floes by the subsidence. The flood carries it away in the usual manner, but where there are variations in the breadth of the channel a jam may take place in a narrow part, and the ice becomes piled. The blocks coming down with the ebb accumulate at the jam, and as the tide recedes lower and lower, the whole tide-way becomes filled up, and the mass freezes together, forming a solid ice jam of immense weight and extent.

I have not seen this phenomenon; but I am convinced that in certain seasons and at particular places it sometimes takes place. During the present unusually severe winter, the great ice sheet formed by the freezing together of the ice-blocks has remained fixed for many days, in some of the estuaries leading into Cornwallis Basin; and a portion of the estuary of the Avon, containing an area of about twenty square miles, has been completely blocked up from shore to shore, the ice extending in one rugged sheet from below the village of Hantsport, as far as the eye could reach, up to the town of Windsor. It rises and falls with the tide, and it is easy to see how a barrier may be formed to the rising tide if it has not the power to force its way beneath the mass; it must spread over the marshes or flats, and begin the formation of a new river channel, at the ebb. It is not difficult to imagine the occasional occurrence of this phenomenon during the long history of an estuary, and it will afford an easy explanation of the changing of river channels, and the erosion of wide valleys now occupied by insignificant streams. During the subsidence and elevation of continents, an immense area must have been subjected to these tidal ice-phenomena during past ages, and it is apparent that both in erosion and transportation, tidal ice has exercised a vast power in moulding the valleys subject to its influence.

Commingling of Débris and Drift by Ice Blocks.

In the Basin of Minas there are three great estuaries, one at the mouth of the Avon, another at the mouth of the Cornwallis River and a third at the mouth of the Shubenacadie, at the head of Cobequid Bay.

At the first named, spring tides rise 48 feet; at Cornwallis River, a little less; and at the mouth of the Shubenacadie, they may attain 65 to 70 feet. The tide rushes through the channel leading into the Basin of Minas at a speed of from seven to eight knots an hour on the south side.* At its narrowest part this channel is about four miles broad, but from 30 to 57 fathoms deep. The tides divide after entering Minas Basin into two parts, one flowing into Cobequid Bay, the other into Windsor Bay. The Windsor Bay tide again divides, one current flowing up the Avon estuary, the other up the Cornwallis River estuary. At ebb tide, blocks of ice, loaded with sand, gravel, and shingle, are carried down the Avon into Windsor Bay, and if the wind serves during the stand, they may drift either into the range of the Cornwallis or Shubenacadie flood tide; and, as the case may be, are carried into one of those estuaries. The reverse of this interchange of range takes place, and Shubenacadie River ice blocks may drift into the Avon or Cornwallis Rivers. Consequently debris from Triassic Trap and Lower Carboniferous rocks become commingled, and materials from different rock systems may

* *Vide* Tyndall on "Regelation."

* Sailing Directions.

thus find their way to positions the reverse of the supposed direction of ice drift; and this explanation may apply to far wider areas under different conditions of sea level, climate, and coastal configuration. In order to arrive at an approximate estimate of the quantity of tidal mud daily transported up and down the estuaries, I selected portions of two average blocks of ice, one having been frozen to the bottom and subsequently liberated, the other, tidal ice, which did not show any signs of having grounded. Both were seamed with light chocolate coloured lines of fine mud, and more resembled dirty rock-salt in appearance than ice.

Block No. 1, or the block which had grounded, contained a proportion of 7 ounces of tidal mud in one cubic foot.

Block No. 2, contained about 3 ounces of tidal mud in the cubic foot.

The average of the two being five ounces of mud to the cubic foot of ice.

Assuming the ice-blocks, when aggregated at the flood tide in an estuary, to cover the surface approximately measured late in January of this year, in the Avon, as follows:

Breadth.............	3,000 feet, or about ½ a mile,
Length...............	50,000 feet, or about 10 miles,
Thickness, average.	4 feet,

the total quantity of tidal mud carried by this ice-field amounted to 93,750 tons. A strong south wind would blow the mass with the ebb tide into Windsor Bay, and into the tidal current leading into Cornwallis River estuary, where much of it would be deposited.

7. THE SWING OF THE TIDES OF THE BAY OF FUNDY.

Standing on the bold mural cliffs facing Chignecto Channel, leading to Cumberland Basin, where Sir William Logan made his celebrated section of the carboniferous rocks of Nova Scotia, the observer may look upon the broad expanse at his feet, any time during January, February, and March, and in some years to the middle of April, and watch the ice floes drifting with the tide. If there be a prominent mark, such as sometimes occurs late in April namely, a too venturous schooner caught in the ice, he may gaze upon the mark drifting with the flood and ebb, forwards and backwards for weeks together, in a huge swing up and down an inclined plane, and within a range varying from twenty to thirty miles.

Selecting [illegible] the tide [illegible] the highest tides occur (head of Cobequid Bay spring tides), we may stand face to face with a tide which rises in six hours thirty-five feet above the mean level of the sea, and, in six hours more, falls nearly thirty-four feet *below* the mean level of the sea.* Going lower down the bay to Noel, and adopting the low estimate of the Admiralty charts, we may in six hours witness the tide rise twenty-five feet above, and sink in the following six hours twenty-four feet below, the mean level of the sea. In Cumberland Basin, where one terminus of the Baie Verte Canal is proposed to be situated, the mean range of high water, that of the plane of the marshes, carries it nineteen feet above the mean level of the sea, and its swing sinks it eighteen feet below.

Theoretically, the rise above the mean level of the sea and the fall below it should be the same; the difference observed in Mr. Baillairgé's tables are, however, slight, and would no doubt be less if the mean level of the sea, to which they are referred, were accurately ascertained by observations continued for a longer period. It is also to be noticed that the tidal record extends only to day tides, no observations having been taken to ascertain the altitude of night tides. As there is a difference between the day and night tides, the night tides being the highest in the Bay of Fundy, an addition of a constant yet to be ascertained will have to be made to all the figures showing the range of the tides.

We may now see without difficulty how it is that ice, vessels, and indeed any floating object, moving with the tide from four to eight miles an hour, may drift backwards and forwards for a space of twenty or thirty miles, or until the ebb meets the incoming flood, and this for weeks and months together, not only in estuaries and the tidal portions of rivers, but on the open bays themselves. This drifting is a swing too and fro, with brief intervals of rest at the "stand" or each turn of the tide, and it is continued up and down an inclined plane four times every day, throughout the winter, throughout the year, in a word, throughout time. A floating block of ice or a vessel descends

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* *Vide* Mr. P. S. Hamilton's paper, before referred to (On the Tides in the Bay of Fundy). Transactions of the Nova Scotian Institute.

ith the ebb, passes the mean level of the
a, and continues to descend to low water,
here, after a brief interval of rest, it meets
ie incoming flood, which carries it up the
clined plane to the place whence it had
t out on its monotonous journey. Down
ie inclined for six hours, and up the in-
ined plane for six hours, and so on without
asing.

RELATIVE EROSIVE AND TRANSPORTING POWER OF THE FLOOD AND EBB.

It now remains to consider the effect of ie tides upon the different kinds of materi- conveyed from place to place by the ice locks during their winter work. It is clear iat the shingle, stones, and fragments of ocks or boulders will generally remain where iey are dropped for one season at least. The ne mud and sand will be distributed by ie tides according to the transporting power f the flood and ebb: and these great tidal urrents differ very materially in their action the Bay of Fundy; they operate, it must e observed, essentially as currents, and not s breakers on an open sea-coast. Of two urrents possessing equal volume, and flow- ig in similar channels, that which has the reatest velocity will necessarily possess the reatest scouring influence.

Mr. Baillairgé's observations included the ourly rate of rise of the tide, and the rate f fall, in feet, by which we are enabled to orm an opinion of the rapidity of the cur- ent during flood and ebb tides.

In all cases the duration of the fall or ebb xceeded the duration of the rise or flood of ie tide.

From Mr. Baillairgé's tables it appears iat the mean duration of rise was five hours nd thirty-two minutes, the mean duration f fall six hours and thirty-five minutes, iowing a difference of one hour and three inutes.

In other words the ebb tide was one hour id three minutes longer in falling than the ood tide in rising through the same vertical stance. From this apparent difference in e velocity of the flood and ebb tides we iould infer that the transporting and erosive ower of the flood was greater than that of e ebb tide. But it will be shown hereaf- r that the ebb carries by far the largest nount of water arising from the drainage of imerous rivers, and consequently requires nger time to pass any fixed point.

But there is a phenomenon of singular interest developed by Mr. Baillairgé's valuable observations, which shows itself not only in the different velocities of the currents during the ebb and flood, but especially in the distributions of these velocities through the different hours and half hours of the flood and ebb.

In his table, it is shown that while during the rise of the tide, the flux, during springs, is extremely irregular, during ebbs, it is *comparatively* an even and tranquil flow. On the 25th of October, 1870, the flood rose 47 feet 8 inches in six hours, but no less than 30 feet 11 inches rushed in during the first three hours, and during the second and third hours of the flood the waters rose 22 feet 10 inches. We may form some conception of the titanic forces exercised by a flood tide rushing in with such "Eygre" like violence as to rise that height in such a short space of time. According to the limited number of observations made at the period of change or new moon in Cumberland Basin, the following were the elevations attained during the second and third hours of the flood in August, September, and October, 1870.

Date. 1870.		Rise of Tide during second and third hours of Flood in feet.
August	31st.	20 feet 9 inches
September	27th.	22 " 8 "
"	30th.	19 " 11 "
October	25th.	22 " 10 "
"	28th.	20 " 6 "

If observations had been made during the night, when the tides are higher in the Bay of Fundy than during the day-time, and continued so as to embrace the vernal equinox, there can be no doubt that the records would show a greater rise during the second and third hours of the flood, and consequently fiercer and more uncontrollable currents, than those indicated by the rush of waters in the table given. It is a rush down an inclined plane, urged by a tidal wave. The ebb obeying the law of gravity descends, so to speak, just as much below the level of the sea as the flood is forced above it by the tidal wave.

Standing on the dykes of Cumberland Basin, the observer, at the close of the ebb, may be said to look upon the bottom of the ocean laid bare twenty-four feet below the mean level of the sea, by the backward swing of the ebb momentum, carrying it as much below the mean level of the sea as the moon and sun's attractions, assisted by the configuration of the land, elevated the waters of the flood tide above it.

What eroding and transporting power tidal-ice must have had in all countries and climates, where configuration of the land thus elevated the tides, and winter cold caused the formation of tidal-ice!

It is not improbable that many of the fiords which distinguish the coast line of countries lying north of the 40th parallel have been moulded or enlarged by tidal-ice, independently of glacial action; and vast surfaces must have been exposed to the action, as already stated, during periods of gradual submergence and emergence in the Northern and Southern temperate zones. It is to the terrific rush of the flood-tide over its bed that the excessively turbid character of the tidal waters in the upper part of the Bay of Fundy is due. The "Eygre" grinds the shingle into minute particles, sorts the debris into mud and sand; much of the mud is carried suspended, even to the top of the flood, and the sand is distributed in the form of bars which are remodelled by the ebb.

As a general principle Mr. Mitchell* states that "a greater proportion of the scour of channels is executed by the ebb than by the flood, because the former is *concentrative*, while the latter is *dispersive*." He illustrates his argument by showing that the tide-wave travels more rapidly in deep than in shallow water; so that in the middle of the bay the water is more elevated on the rise and less elevated on the fall than along the shore; the rise is therefore attended by a current pressing shoreward, while the fall induces a running in toward a central axis. The consequence is, that although the inflowing and outflowing volumes may be equal, in a supposed case, the ebb, *concentrated*, is more rapid, and therefore plays the greater part in excavating a central channel-way to the sea.

The proposition is no doubt [illegible]stained in all cases where the ebb a[illegible]ood have nearly the same duration, and particularly when the ebb is of shorter duration than the flood, as is not unfrequently the case on the open Atlantic Coast. The flood current, pressing shorewards during the rise, is of vast importa[illegible] in connection with the [illegible]tion of ice, for it presses shorewards in [illegible]ing the great bend in Cumberland Basin, and in many other land-locked water are[illegible]. The scouring of the flood and ebb tides there may take place in the following manner:—

The flood-tide, entering the basin with great rapidity, carries along with it [illegible] and sand, and the wear of the coast and [illegible], which it throws off shorewards, and distributes the heavier particles on the sloping beach on either side. During the stand the mud and sand are deposited. The ebb, assisted by the waters of all the rivers flowing into the area under review, carries back a portion of the fine mud and sand towards the centre of the channel, where the current is strongest, and then conveys a part back to the deeper portions of Cobequid Bay. The resultant of these antagonistic operations is seen in the accumulation of mud on the marshes and of sand on the bars; but the *amount* of mud and sand thus deposited is, in the aggregate, less than that which is conveyed by the ebb-tide towards Cobequid Bay, otherwise the basin would long ere this have been silted up. The ebb has to convey the drainage of a large extent of country, the accumulated waters of the Maccan, the Hebert, the Napan, and many other streams of less dimensions; hence, though the duration of the ebb is longer than that of the flood, we may not infer that its current is less potent, for it has a much larger body of water to discharge. Mr. Page states that the current of the outgoing tide *is stronger* than when it is rising; and it is by observing the direction and shape of the bars and flats that we are enabled to arrive at the conclusion that the ebb exercises the greatest scouring effect in the basin. The direction of a current is shown by the shape of a bar, either in mid-stream, or with one extremity joined to the land. The bars in Cumberland Basin point seawards;—that is, their broad base is landwards, their narrow extremity seawards. The great expanse of sand, forming Minudie Quicksands, turns its north western point seawards; hence, it appears that the resultant of the two currents, flood and ebb, is in favour of the ebb.

In the shape of the coast where the marshes have been deposited, we recognise the grand effect of the flood-tide. The shore line there formed is a smooth and sustained

* United States Coast Survey, 1869.

outline, along which the flood-tide throws the ice, and compels it to hug the shore in its transit round the Basin. Any obstruction, natural or artificial, would have to bear the brunt of the ceaseless attacks of innumerable cakes of ice loaded with mud; and in the gravel deposit, described by Mr. Baillairgé, we may recognise the influence of the transporting power of ice. A literal cordon is thus formed, which protects the banks, just as a cordon is produced by the breaking wave of the sea when a headland is worn down. If we knew the mineral character of the boulders, shingle, and gravel lying near the mouth of the Missaquash, the La Planche, and Cumberland Creek, we could tell whether they originated by the wear of a former headland, such as Cumberland Ridge, or St. Lawrence Ridge, or whether they are constantly brought by ice, from headlands lying seawards with the flood-tide, and thrown off towards the margin of the marshes, where they now act as a protecting shield. It is probable, under all circumstances, that if these boulders were removed the banks would be undermined. Hence the nature of this littoral cordon becomes a subject of interesting enquiry with regard to an anchorage ground at the mouth of the Baie Verte Canal. In many of the Bay of Fundy harbours, vessels loading or discharging rest on soft mud when the tide is out. But if boulders are liable to be deposited in the mud, this would be a very dangerous expedient.

9. THE EFFECT OF OBSTRUCTIONS IN THE FORM OF PIERS IN THE TIDE-WAY.

The present relative position of the marshes, bars, channel, and coast line is the resultant of ages of action on the part of the flood and ebb tides, and it becomes an interesting subject of enquiry to determine the extent of the readjustment which would probably be produced by changing the direction of the fierce currents which sweep through Cumberland Basin, by the construction of piers at the entrance of the proposed Baie Verte Canal.

Selecting the best locality for the terminus of the canal, where all are bad, Mr. Baillairgé suggests a pier, 1,500 feet long, at Au Lac Point. According to Mr. Page, the slope of the bottom of the Basin at this point is as follows :—

In the first 500 feet the slope from the surface of the marsh is.	18.77	feet.
In the next 300 feet......................	5.00	"
In the next 400 feet..................	12.00	"
Total slope in 1,200 feet......... ..	35.77	"

The construction of a pier 1,500 feet long on this slope, will be about equivalent to a pier 1,000 feet long and 17.88 feet deep in the tide-way. The sectional area of the whole tide-way, or channel, from Au Lac Point to the dykes of the Minudie marshes on the opposite side of Cumberland Basin is, according to the Admiralty chart, about as follows, but actual measurement may considerably modify these estimates :

Breadth of channel........	2.80	miles.
Distance of middle of channel from Au Lac Point	0.606	"
Distance of middle of channel from Minadie marsh...... ...	1,194.00	feet.
Depth of water in channel at low water................	12.00	"
Depth at high water	54.00	"
Approximate sectional area of channel at high water...... ...	27.701	sq. yards.
Approximate sectional area of pier	1,800	"

The obstruction to the tide-way would be equivalent to reducing its present available sectional area across the basin. Its effect would be felt chiefly in the diversion of the currents and their increased velocity. The same quantity of water must come up to the pier, but the tide-way being diminished, a portion of the flood, which hugs the Au Lac shore, would go up the Tintamarre river, and probably overflow the dykes and flood the present marshes throughout Cumberland Basin. The current past the end of the pier would be vastly increased, and if we regard the rising flood as a river, with the pier as a wing dam, the effect upon the elevation and velocity of the water would be in most respects similar. The quantity of water passing up the Maccan and Hebert rivers would be lessened, and some effect produced upon the sand bars, and also upon the navigation of these rivers.

Mr. Page describes the existing currents at Au Lac Point, from which we may infer the extent of the eddies which would be produced by a pier 1500 feet long, and form a conception of the nature of the deposits which would gather by means of the transporting power of the ice-blocks in winter, as already described.

The effect of the eddies referred to in Mr. Page's description appears to be shown on the Admiralty chart by a circular sand bar lying due south of the Tintamarre river. It would be interesting to know whether the substratum of this bar, or even part of the bar itself, does not consist of gravels and shingle deposited by ice during winter, and covered with sand during summer.

There can be little doubt that an eddy of considerable magnitude would be produced during flood tide, on the east side of the pier farthest from the flood, and at ebb tide on the west side farthest from the ebb. Here, bars, or rather accumulations of sand, would be produced by the debris melted off the bottom of the ice-blocks. But these incessant carriers bring gravel and shingle besides mud, which, when dropped in the eddy, would be sorted, but not carried away, as they would lie under the protecting shelter of the piers. But they would gradually invade the entrance to the canal, and the accumulation would take place uninterruptedly during three or four *winter* months, when no dredging operations could be carried on, with a rapidity only to be appreciated by those who have watched the effect produced by the mud-ice of the Bay of Fundy.

It has been shown that the construction of a pier 1500 feet long at Au Lac Point, where the tide-way is 2.8 miles broad, would exercise a very material influence upon the bars and marshes, and upon the velocity and direction of the currents; and it may with propriety be asked, what effect would a pier 2500 feet long, as suggested by Mr. Keefer,* produce in a tide-way, where the sectional area is only one-half of that opposite the mouth of the Au Lac?

It would certainly deluge the Cumberland marshes, sweep away the Minudie marshes, and probably soon convert the pier into an island, by [illegible] What would be [illegible] feet long, constructed in [illegible] a swift flowing river [illegible], or even [illegible] that distance, in breadth?

10. CONCLUSION.

The ice drifts and the tidal currents of the Bay of Fundy present, I venture to suggest, an insuperable objection to the construction and maintenance of piers similar to those proposed at the mouth of the Baie Verte Canal in Cumberland Basin. The construction would involve the raising of the dykes by several feet all round the basin, and a corresponding increase to their strength. The winter frosts would fill the slip formed by the piers with a solid and uniform mass of tidal mud-ice, which would protract the opening of navigation for some weeks. The eddies produced, would rapidly promote the formation of bars or deposits on the outside of each pier, which would gradually invade and ultimately block the entrance to a greater or less degree, and dredging operations would be very difficult. The remedy for these objections is apparently simple, if the expense be not too great, and if the purposes of navigation can be served. The mouth of the canal must be flush with the shore line, and constructed at a point where solid rock forms the shore. This, I believe, exists some short distance south of the mouth of Tintamarre river. The mouth of the canal must be closed during the winter, to prevent the *growth* of tidal and mud-ice within it, or it will be filled with a solid mass of ice during the winter, like the open slips at different parts on the upper part of the Bay of Fundy.

These are the deductions to which a study of the ice-phenomena of the Bay of Fundy necessarily leads, and which cannot be overlooked in preparing for the construction of such an important national work as the Baie Verte Canal.

* *Vide* Mr. Page's analysis of Mr. Keefer's Report, page 11, Baie Verte Canal Reports.